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मानक

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IS 3872 (2002): Lining of Canals with Burnt Clay Tiles -
Code of Practice [WRD 13: Canals and Cross Drainage Works]



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भारतीय मानक
नहरों की अस्तर के लिए पकी मिट्टी की
टाइल — रीति संहिता
(पहला पुनरीक्षण)

Indian Standard
LINING OF CANALS WITH BURNT CLAY
TILES — CODE OF PRACTICE
(*First Revision*)

ICS 93.160

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Canals and Cross Drainage Works Sectional Committee had been approved by the Water Resources Division Council.

Lining of canals is considered as an important feature of irrigation projects as it not only minimizes the loss of water due to seepage but also results in achieving considerable economy in the use of cultivable land which would otherwise be prone to water-logging due to rise in water table. Further, the water, thus saved, can be usefully employed for the extension and improvement of irrigation facilities. Lining of water courses in the areas irrigated by tube-wells assumes special significance as the pumped water supplied is relatively more costly.

Further, lining of canals permits the adoption of high velocities resulting in proportionate savings of the cross-sectional areas of the channel and land width required with corresponding saving in the cost of excavation and masonry works which may in certain cases offset completely the extra cost of lining. Also, the lining ensures stability of channel sections thereby reducing the maintenance cost. The benefits that accrue from lining of canals generally justify the initial capital cost and because of this there is now better appreciation of the need for lining of canals.

Judicious selection of serviceable and economical lining at the first instance and subsequently proper execution of the work while laying the canal lining reflects considerably in achieving overall economy in the project.

Clay tile lining has its own advantages particularly where suitable soils for burning of tiles are available in the neighbourhood of canals.

Considerable experience is available in the country with regard to clay tile lining which has been carried out on a large scale for lining of Bhakra Canal, Rajasthan Canal and several other canals in various states. The experience pooled by the engineers of the country drawn from various organizations and the extensive investigations and research work carried out by different research organizations with regard to single tile lining and double tile lining has been of considerable value in the preparation of this standard.

This standard was first published in 1966. The revision of this standard has been taken up to incorporate the latest technological changes in this field as well as to account for the experiences gained during the last four decades.

There is no ISO standard on the subject. This standard has been prepared based on indigenous data/practices prevalent in the field in India.

The composition of the Committee responsible for formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

LINING OF CANALS WITH BURNT CLAY TILES — CODE OF PRACTICE

(*First Revision*)

1 SCOPE

This standard covers laying and finishing of burnt clay tiles on beds and side slopes of canals to serve as canal lining.

2 REFERENCES

The following Indian Standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<i>IS No.</i>	<i>Title</i>
269 : 1989	33 Grade ordinary Portland cement (<i>fourth revision</i>)
455 : 1989	Portland slag cement (<i>fourth revision</i>)
456 : 2000	Code of practice for plain and reinforced concrete (<i>fourth revision</i>)
1489	Portland Pozzolana cement :
(Part 1) : 1991	Flyash based (<i>third revision</i>)
(Part 2) : 1991	Calcined clay based (<i>third revision</i>)
1542 : 1992	Sand for plaster (<i>second revision</i>)
2116 : 1980	Sand for masonry mortars (<i>first revision</i>)
2250 : 1981	Code of practice for preparation and use of masonry mortars (<i>first revision</i>)
2720	Method of test for soils: Part 7
(Part 7) : 1980	Determination of water contents — Dry density relation using light compaction (<i>second revision</i>)
3367 : 1993	Burnt clay tiles for use in lining irrigation and drainage works (<i>second revision</i>)

*IS No.**Title*

8112 : 1989 43 grade ordinary Portland cement (*first revision*)

12269 : 1987 53 grade ordinary Portland cement

3 TERMINOLOGY

For the purpose of this standard the following definitions shall apply:

3.1 Lip Cutting

It is the extra width provided at the inner face of the bank under compaction to allow for any lapses in compaction due to the inability of sheep-foot rollers to cover the edge of the bank.

3.2 Made-up Ground

Excavated soil or rock deposited for the purpose of filling a depression or raising a site above the natural level of the ground.

3.3 Subgrade

The surface specially prepared against which lining shall be laid.

4 NECESSARY INFORMATION

The following information shall be procured for the entire length of the canal before commencing the work:

- a) Nature of soil (physical properties) up to suitable depth below the canal bed,
- b) Sub-soil water level,
- c) Salt contents of soil, and
- d) Longitudinal section and cross-sections of the canal.

5 MATERIALS**5.1 Cement**

Cement conforming to IS 269 or IS 455 or IS 1489 (Part 1) or IS 1489 (Part 2) or IS 8112 or IS 12269 as specified by the engineer-in-charge.

5.2 Sand

Conforming to IS 2116 or IS 1542 as specified by the engineer-in-charge.

5.3 Tiles

Tiles used for lining canals shall conform to IS 3367.

5.4 Water

Water used for both mixing the mortar and curing shall be conform to the requirements specified in IS 456.

6 PREPARATION OF SUBGRADE

6.1 Reaches with Expansive Soils

Lining should be avoided, as far as practicable, on expansive clays. But, if the canal has to traverse through a reach of expansive clay and no alternate route or construction type is economically feasible any one of the practices detailed under 6.1.1 and 6.1.2 shall be adopted to reduce to the damage to the lining depending upon the swelling properties of the soil encountered.

NOTE — Clays vary so much in characteristics that the pressure required to prevent expansion may be less than 0.07 kg/cm^2 in some types and as much as 10.5 kg/cm^2 or higher in others. In many cases the practices recommended in 6.1.1 and 6.1.2 may not be adequate needing detailed investigations to find out a practicable solution.

6.1.1 If the expansive clay is in thin layer or in small pockets in an otherwise suitable subgrade it shall be over-excavated and replaced with a suitable non-expansive soil and compacted suitably.

6.1.2 If the swelling of the clay encountered can be controlled by loading the surface with a non-expansive compacted soil or gravel; the expansive clay bed shall be over excavated to a depth of about 600 mm and filled to the grade of the underside of lining with good draining material leading away the seepage water to specially constructed points either to the outside of the canal or releasing it into the canal through suitable pressure relief valves. However, the excavated surface of expansive clay shall be given a coat of asphalt before loading it to prevent the entry of water into the clay.

6.2 Under Drainage

For a lined canal where the ground water level is higher or likely to be higher than water level inside the canal so as to cause damaging differential pressures on the lining; or where the subgrade is sufficiently impermeable to prevent free drainage of the underside of lining in case of rapid draw down, pressure relief arrangements for under drainage shall be provided.

6.3 Anti-Salt Treatment

Soil in all reaches shall be tested for salt contents before the lining is started. Where the salt content is over 1.00 percent, or sodium sulphate is over 0.36 percent, the subgrade shall be first covered with about 2 mm

thick layer of bitumen obtained by evenly spraying bitumen at a rate of about 2.35 l/m^2 . To get a good bond between bitumen and soil, crude oil at a rate of 0.5 l/m^2 shall be sprayed over it in advance of spraying bitumen. In case such a situation is encountered only in small pockets the replacement of subgrade up to a suitable depth by suitable earth from adjoining reaches should be considered, if economical.

6.3.1 Before spraying crude oil, subgrade shall be perfectly dry, clean and free from dirt and crude oil shall be allowed to penetrate the subgrade surface. Bitumen shall be heated to a temperature of 175°C and applied to the subgrade by a suitable pressure sprayer. Immediately following the application of bitumen, dry sand shall be uniformly spread. Lining should be started 6 to 12 h after spraying.

6.4 Preparation of Subgrade Consisting of Rock

The subgrade shall be prepared and dressed true to level and according to the required cross-section of the canal.

6.4.1 All excavation including over-breakage below the grade of underside of lining shall be filled completely up to the grade of the underside of lining with suitable material. Care shall be exercised in selecting refill material for use over fractured rock or cobbles because of the danger of washing fines into the subgrade voids and thus losing support, the selected material shall be such as to resist such piping and otherwise should be selected for impermeability and ease of placement.

6.5 Preparation of Subgrade Consisting of Earth

The subgrade shall be prepared, dressed and rolled true to level and according to the required cross-section of the canal to form a firm compacted bed for the lining.

6.5.1 In other than predominantly sandy reaches where the dry bulk density of the natural soil is not less than 1.8 g/cm^3 , initial excavation shall be done up to about 300 mm above the final section and the cutting to final shape shall be done immediately before lining (*see also 6.5.6*).

6.5.2 Sample profiles true to the cross-section of the canal shall be made at suitable intervals to ensure correct formation of subgrade. To ensure uniformity of side slopes a chord shall be stretched across two profiles over a spacer of uniform thickness of 12 mm. A third spacer shall be run under the chord to check the evenness of the surface. This process shall be repeated at short intervals along the slopes till the surface between two profiles is properly levelled and dressed from top to bottom. Suitable wooden templates may be used to layout and check the profile.

NOTE — In straight reaches an interval of 3 to 4 m is recommended for sample profiles.

6.5.3 If at any point material of prepared subgrade has been excavated beyond the neat lines required to receive lining, the excess excavation shall be filled with material compatible with subgrade material and thoroughly compacted in accordance with 6.5.5 and 6.5.6.

6.5.3.1 When partial filling of an existing canal is necessary to reduce the cross-sectional area to that required for lined canal the fill shall be placed and suitable compacted to avoid its settlement and rupture of the lining.

6.5.4 To cover up any lapses in the compaction of the inner core of the banks near the edges and to allow sufficient width for a labourer to work conveniently a lip cutting width of not less than 500 mm horizontally shall be provided. Depending upon the nature of soil and the side slopes of the canal, the lip cutting width may be in the range of 500 to 1 000 mm (see Fig. 1C).

6.5.5 *Compaction of Subgrade in Predominantly Sandy Reaches*

6.5.5.1 *Bed*

The consolidation of the bed shall be done by over-saturating the bed by flooding it with water before lining is laid.

6.5.5.2 *Sides*

The consolidation of sides shall be done either by over cutting the subgrade by 150 mm and refilling it with sand concrete with adequate quantities of lime or cement or by vibro-compactors.

NOTE — Admixtures of 5 percent cement is generally found satisfactory.

6.5.6 *Compaction of Subgrade in other than Predominantly Sandy Reaches*

All compaction shall be done at optimum moisture content in layers not more than 150 mm thick to obtain a dry bulk density of not less than 95 percent for bed and 90 percent for sides of the density at optimum moisture content obtained in accordance with IS 2720 (Part 7).

6.5.6.1 Where the dry bulk density of the natural soil is equal to or more than 1.8 g/cm^3 the procedure described in 6.5.1 shall be followed.

6.5.6.2 *Bed*

Where the dry bulk density of the natural soil is less than 1.8 g/cm^3 and the sub-soil water is near the subgrade the consolidation shall be done by undercutting the bed by 75 mm and then ploughing up to 150 mm below the subgrade level. The loosened soil shall then be recompact with sheep-foot rollers or other suitable devices.

Where the subsoil water is low, requiring no dewatering and the dry bulk density of the natural soil is less than 1.8 g/cm^3 , the consolidation shall be done by digging the canal up to subgrade level and thereafter loosening the earth below subgrade up to 150 mm. After that the second layer of 150 mm of earth shall be laid over the compacted layer by taking earth from lip cutting and compacting this to a depth of 110 mm. The compacted layer of 70 mm above the subgrade level shall be removed and the subgrade brought to design profile before laying the lining.

6.5.6.3 *Sides*

Consolidation on sides shall be done by manual labour or suitable compactors to a depth of 300 mm to obtain a minimum dry bulk density of not less than 90 percent of the density at optimum moisture content obtained in accordance with IS 2720 (Part 7).

7 *DESIGNS CONSIDERATIONS*

7.1 *Layers of Tiles for Bed and Slide Slopes*

The lining may consist of single tile lining or double tile lining as specified by the engineer-in-charge (see Fig. 1A, 1B, and 1C).

7.1.1 *Bed*

7.1.1.1 *Single tile lining*

This shall consist of single layer of burnt clay tiles laid on about 10 mm thick 1 : 5 cement mortar on the well dressed subgrade (see Fig. 1A). Joints shall be well filled with mortar of the same consistency. Joints shall then be raked to 12 mm depth, and after that not less than 20 mm thick cement plaster 1 : 3 shall be laid on it, which shall be given smooth finish. The mortar shall be laid on 6 m lengths; the lengths being laid alternately. The total thickness of lining shall be not less than 80 mm. The thickness of joints shall not exceed 10 mm.

7.1.1.2 *Double tile lining*

This shall consist of double layer of tiles, with a sandwiched layer of cement mortar, laid in accordance with 7.1.2.

NOTE — However, the first layer of tiles in the canal bed may be allowed to be replaced by 75 mm thick 1 : 3 : 6 brick-bat cement concrete with necessary modifications in the rates of the items. This change shall be allowed only to the extent required for utilizing the broken tiles accumulated on the site due to normal breakages during the course of the work.

7.1.2 *Side Slopes, Double Tile Lining*

The sides shall consist of double layer of tiles with not less than 15 mm thick sandwiched layer of cement mortar of 1 : 3 mix. The first layer of tiles shall be laid

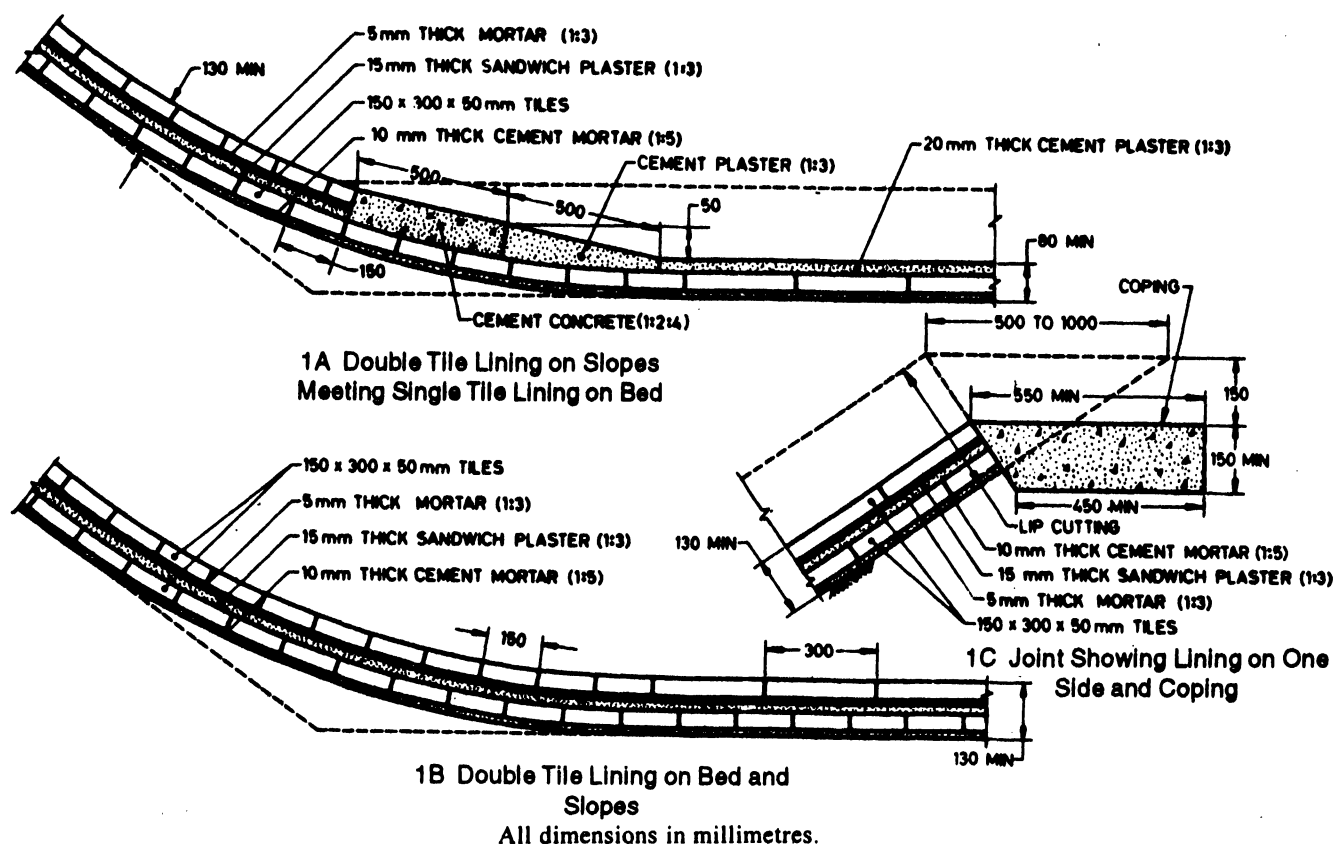


FIG. 1 TYPICAL SKETCH OF CANAL LINING WITH BURNT CLAY TILES

on about 10 mm thick 1 : 5 cement mortar spread on compacted subgrade dressed to specified slope. The joints shall be filled with mortar of the same consistency. The first layer of tiles shall be covered with 1 : 3 cement plaster not less than 15 mm thick on the top of which second layer of tiles shall be laid in about 5 mm thick 1 : 3 cement mortar except for the bottom one metre length before its junction with single tile lining in the bed. The last metre in such case shall be joined to the single tile lining in the bed by laying 1 : 2 : 4 cement concrete in half metre width and by laying 1 : 3 cement mortar in the rest half. Total thickness of lining masonry shall be not less than 130 mm (see Fig. 1A and 1B).

7.2 Thickness

The thickness of joints shall not exceed 10 mm.

7.3 Mix for Cement Mortar

7.3.1 The following proportions for cement mortar shall be used for lining works. However, the mortar shall conform to IS 2250:

- For 10 mm thick cement mortar subgrade 1 : 5 by volume
- Mortar for masonry of first layer of tiles 1 : 5 "
- For 15 mm thick sandwich cement and sand plaster 1 : 3 "
- For 5 mm thick cement and sand mortar and for tile masonry for top layer 1 : 3 "

- For 20 mm thick cement and 1 : 3 by volume sand plaster over the layer of tiles for single tile lining in bed

7.3.2 The use of admixtures including water proofing compounds may be permitted if approved by the engineer-in-charge.

8 TOP COPING

To check the leakage of rain water behind the lining in sides, not less than 150 mm thick cement concrete coping of Grade M-10 conforming to IS 456 or of a double layer of tiles with a mortar mix specified for slopes (see 7.3) shall be provided horizontally on the top of the lining (see Fig. 1C). The width of the coping at the top shall not be less than 350 mm.

9 PRELIMINARY WORK

9.1 Hump

Humps of concrete or masonry about 150 mm high shall be provided where necessary in the bed of the canal at every 300 m intervals, to ensure that during short closures the bed of the canal does not dry and thus does not expose the plaster to direct rays of sun which may otherwise result in formulation of cracks.

9.2 Soaking of Tiles

Arrangements shall be made by those engaged in the work and so regulated that tiles properly soaked in water for at least four hours are available for carrying

out the work during each day.

10 LAYING OF TILES — PHASED STEPS

10.1 Laying of First Layer of Tiles — First and Second Day Programme

10.1.1 The lining shall be started only when at least 35 m length of canal with subgrade is properly dressed to receive lining. Necessary arrangement for proper soaking of tiles, mortar mixing arrangements and sufficient number of tiles shall be made available before starting the work.

10.1.2 Where spring level is high the water table shall be lowered to at least 30 cm below the subgrade by dewatering.

10.1.3 The subgrade shall then be uniformly soaked with water without making it slushy to ensure that water penetrates to a depth to about 300 mm in sandy soil and about 150 mm in other soils. Wetting of subgrade shall continue in advance of laying of tiles so that the soil does not absorb moisture from 10 mm thick mortar laid on the subgrade for laying the layer of tiles.

10.1.4 Single tile profiles of lining parallel to centre line of the canal shall be prepared at suitable intervals. Mortar shall be uniformly spread over the subgrade and the tiles shall be properly laid in position quickly after that. Care shall be taken to see that the vertical joints are completely filled with mortar. The tiles shall be laid in bed at right angles to the centre line of the canal while on the side slopes they shall be laid parallel to the centre line.

10.1.5 Enough number of profiles both in the bed and slopes shall be laid each day so that when the work is started next day the marks shall already be in position. Construction points or panels at suitable width each in bed and sides shall be perfectly rolled, levelled and laid with profiles every day to receive lining of the first layer of tiles on the next day.

10.1.6 Tiles shall be firmly embedded in mortar. Hollows, if any, shall be rectified by relaying the defective portions with fresh mortar.

10.2 Curing and Correction — Third and Fourth Day Programme

On the third day layer of tile shall be kept wet by sprinkling water over it, to keep the mortar well wetted. On the fourth day, the surface shall be kept wet and joints of the tile masonry shall be carefully tested. Hollow joints shall be raked to a depth of 12 mm, loose mortar removed from sides and top of tiles and the joints properly refilled. Any loose tile shall be removed and relaid.

10.3 Laying Cement Mortar Layer — Fifth Day Programme

10.3.1 For Single Tile Lining

Not less than 20 mm thick cement plaster of 1 : 3 mix shall be laid on the completed portion of the bed. To ensure proper thickness of mortar being laid and to achieve perfect level in spreading of cement mortar L-shaped wooden frames of 1 × 1.5 m made of 20 mm thick wooden plankings, shall be used. The plaster shall be well pressed while laying so that any excess of water or air locked into pores is driven out, thereby exercising uniform plaster over the layer of tiles. The surface of the plaster shall be finished even and smoothened after lightly sprinkling it with pure cement. This ensures a smooth hard surface thus checking the erosion of the surface of the plaster by water action.

10.3.2 For Double Tile Lining

When double tile lining is to be laid either on bed or on side slopes, not less than 15 mm thick sandwiched layer of 1:3 cement sand mortar shall be laid by using L-shaped wooden frames of 1 × 1.5 m made of 15 mm thick wooden plankings. This shall be done to ensure that correct thickness of 15 mm is obtained over the whole surface. The plaster shall be well pressed while laying so that any excess of water or air locked into pores is driven out, thereby providing uniform plaster over the first layer of tiles. The upper side of the plaster shall be made rough for proper bond with the upper layer of tiles by means of fibre brushes or brooms. Wire brushes and nails shall not be used for the purpose.

10.3.3 The cement sand plaster shall be kept well wetted on the sixth day.

10.4 Laying Top Layer of Tiles — Seventh Day Programme

10.4.1 The top layer of tiles in case of double tiles lining shall be laid in 1 : 3 cement mortar about 5 mm thick. This layer of tiles shall be laid firmly and properly to proper levels in beds and correct slopes on the sides with joints not more than 10 mm thick.

10.4.2 Tiles used on the top layer shall be the best and laid with greater precision. Vertical joints shall be laid flush with cement mortar and no cement pointing shall be done on top of the tiles. The completed lining shall be checked for level with wooden templates and spirit levels.

11 INSPECTION

11.1 Daily inspection of the work shall be carried out at the site and the joints found empty shall be localized and thereafter filled properly and relaid, if necessary.

The results of inspection may be kept in proper log book.

12 CURING

12.1 Work done on each day shall be kept thoroughly wet for curing. In case of single tile lining, subsequent to laying of cement plaster layer and after 24 to 36 hours; and in case of double tile lining after laying the second layer of tiles, the lining shall be cured for at least 28 days. For bed, this may be done by constructing 150 mm deep earthen bunds across the bed so that a small depth of water shall stand on the upstream of the bunds and curing assured.

12.2 The curing of side slopes may be done by constructing masonry drains with weep holes or perforated pipes on the coping at the top of the lining or by using sprinklers.

13 MAINTENANCE DURING LAYING

During the progressive construction of lining the labour

shall walk on foot-paths of planks provided for the purpose. Walking on layer of tiles, finished plastered surface or the lined portion of the canal unless properly set and cured for a period of 15 days, shall not be permitted. Such irregularities may cause dislodgement of tiles resulting in previous lining.

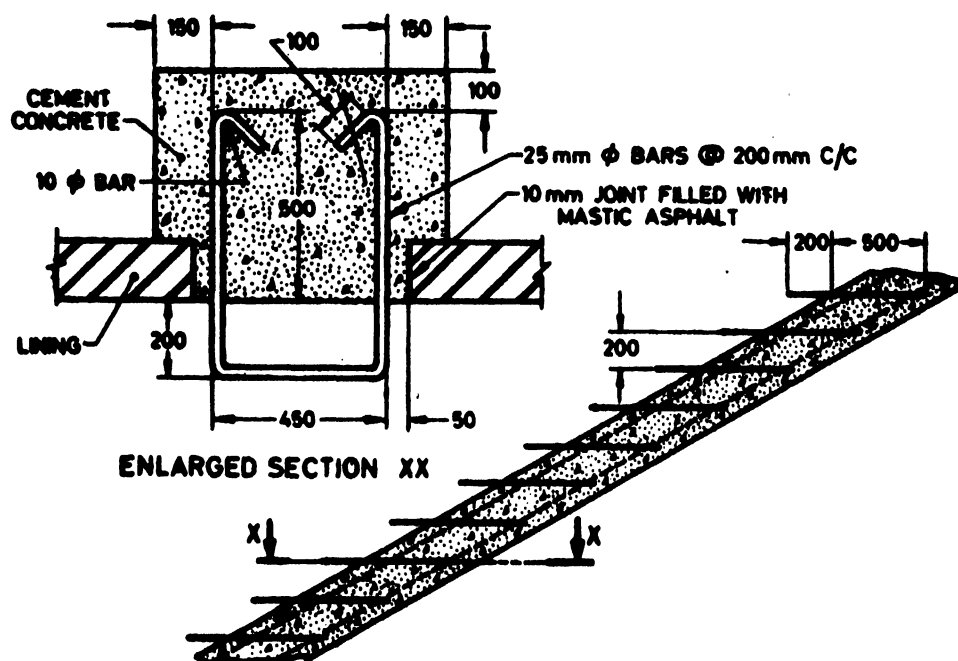
14 SAFETY LADDERS

14.1 Safety ladders shall be constructed in canal lining where shown on the drawings or as directed by the engineer-in-charge.

14.2 Safety ladders consisting of rungs shall be constructed in canal lining about 30 mm upstream of the point where the canal enters some underground structure. In other reaches, safety ladder may be provided at a spacing of about 300 m, the ladders being provided alternately on either sides.

14.3 Ladder rungs shall be smooth round mild steel bars galvanized or coated with coal tar after installation.

14.4 Details of safety ladder are illustrated in Fig. 2.



All dimensions in millimetres.

FIG. 2 DETAILS OF SAFETY LADDERS

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Canals and Cross Drainage Works Sectional Committee, WRD 13

<i>Organization</i>	<i>Representative(s)</i>
Sardar Sarovar Narmada Nigam Ltd, Gandhi Nagar Bhakra Beas Management Board, Nangal Township	SHRI G. L. JAVA (<i>Chairman</i>) DIRECTOR (WR) EXECUTIVE ENGINEER (<i>Alternate</i>)
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Central Water Commission, New Delhi	DIRECTOR [BCD N & W & NWS] DIRECTOR [SSD & C] (<i>Alternate</i>)
Consulting Engineering Services (India) Ltd, New Delhi	SHRI S. P. SOBTI DEPUTY PROJECT MANAGER (<i>Alternate</i>)
Continental Construction Ltd, New Delhi	SHRI P. A. KAPUR SHRI T. B. S. RAO (<i>Alternate</i>)
Indira Gandhi Nahar Board, Phalodi Irrigation Department, Government of Andhra Pradesh, Hyderabad	SHRI. R. K. GUPTA CHIEF ENGINEER SUPERINTENDING ENGINEER (<i>Alternate</i>)
Irrigation Department, Government of Haryana, Chandigarh	CHIEF ENGINEER (PROJECTS) DIRECTOR (ENGINEERING) (<i>Alternate</i>)
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Irrigation Department, Government of Maharashtra, Nasik	SUPERINTENDING ENGINEER (GATES) EXECUTIVE ENGINEER (CSI) (<i>Alternate</i>)
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Narmada and Water Resources Department, Government of Gujarat, Gandhi Nagar	SUPERINTENDING ENGINEER (CDO) EXECUTIVE ENGINEER (UNIT G) (<i>Alternate</i>)
Public Works Department, Government of Tamil Nadu, Chennai	ENGINEER-IN-CHIEF
Reliance Industries Ltd, New Delhi	DR V. K. SAROOP SHRI AVINASH DUBEY (<i>Alternate</i>)
Sardar Sarovar Narmada Nigam Ltd, Gandhi Nagar	DIRECTOR (CANALS) CHIEF ENGINEER (CD/W) (<i>Alternate</i>)
University of Roorkee, Roorkee	SHRI NAYAN SHARMA
Water and Land Management Institute, Lucknow	PROF P. K. SINHA
Water Resources Department, Government of Orissa, Bhubaneswar	CHIEF ENGINEER (D & R)
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Joint Director (WRD), BIS

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002
Telephones : 323 01 31, 323 33 75, 323 94 02

Telegrams: Manaksanstha
(Common to all offices)

Regional Offices :

Telephone

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg
NEW DELHI 110 002

{ 323 76 17
 323 38 41

Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Kankurgachi
KOLKATA 700 054

{ 337 84 99, 337 85 61
 337 86 26, 337 91 20

Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160 022

{ 60 38 43
 60 20 25

Southern : C. I. T. Campus, IV Cross Road, CHENNAI 600 113

{ 254 12 16, 254 14 42
 254 25 19, 254 13 15

Western : Manakalaya, E9 MIDC, Marol, Andheri (East)
MUMBAI 400 093

{ 832 92 95, 832 78 58
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